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Sufficient has been written to show what manner of man Fendler was. It has been more than eighteen months since the writer heard directly from him, and now only the bare fact of his death is known, letters of inquiry directed to persons in authority at Port of Spain remaining unanswered. Those who have been privileged to become well acquainted with him will not soon forget this kindly, simple, honest-hearted man, nor cease to regret that they can no longer enjoy his friendship and correspondence.

On the Perforation of Cells and the Continuity of Protoplasm in Vegetables.

[A note by M. L. Olivier, presented to the French Academy of Sciences by M. Duchartre (*Comptes Rendus*, Tome C, No. 18, May 4, 1885).]

TRANSLATED BY ERWIN F. SMITH.

I. Three years ago I stated* that photography applied to microscopy was capable of showing details of structure which do not impress themselves upon the retina. In support of this assertion, I published† a description of a negative in which may be seen on the cell walls a system of markings and perforations inappreciable with the microscope.

In seeking to perfect this new method of investigation, I have confirmed the existence in vegetable cellular membranes of a system of canals to which I desire to invite the attention of the Academy.

In examining the living tissues of plants, whatever be the magnifying power used, we generally perceive no communication of one cell with another.‡ The small protoplasmic masses which constitute the living matter of each cell have also been considered, up to a recent date, to be absolutely independent and entirely isolated from each other; each one of these little masses appears in fact to be completely enclosed in an alveolus.§ From this view arises the impossibility of attributing to two neighboring protoplasmic masses any other relation than that of osmotic exchange through the solid walls which separate them. Such has been the general conception of the vegetable organization as depicted in the most recent standard works.

My researches have led me to an entirely different result. In the substance of the membranous walls I have observed numerous canals and have ascertained that they insure the continuity of the protoplasm through the cell walls.*

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* *Revue Sci.*, April 8, 1882, 3d series, vol. iii, p. 433.

† *Ibid.* p. 434, and note on p. 435.

‡ Except in the case of sieve tissue of which the wholly special structure and localization in the plant are to-day well understood.

§ The walls of this prison are composed of a ternary substance; cellulose, lignine, cutine, etc.

II. The existence of these extremely tenuous canals, which traverse the cell walls through and through, escapes detection by the ordinary methods of investigation, but may be shown by the employment of the following methods:

1. *Photography.* Thin cross sections are made of living tissues, after growth has ceased. The sections are then photographed *direct* with a magnification of about 300 to 700 diameters. By using for this operation the method I have already described †, we obtain negatives of a peculiar interest. On these negatives, when examined with a lens, the cell membranes appear to have an extremely complex structure‡; they are seen to be variously perforated by canals, transverse or longitudinal, which establish a communication between the contents of the cells.§ It seems impossible to ascribe this appearance of canals on the photographic film to any phenomenon of diffraction.

2. *Direct observation.* After having shown this structure upon my negatives, even upon old negatives which had not been made with reference to the study of cell membranes, I have tried to see it directly. To this end I have examined my preparations, with powers of from 700 to 900 diameters, in a dark chamber into which the microscope projected in such a way that my eye was influenced only by the light proceeding from the instrument. Under these conditions I have succeeded in seeing clearly the interruptions of the cell walls in several plants.‖ Nevertheless, for the most part, this method is wholly insufficient.

3. *Staining sections.* I have obtained a better result by staining in an exclusive way, by means of appropriate reagents, either the cell membranes, or the protoplasmic elements after fixing, turgescence, or contraction. In the first case the cell walls, when

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[*] In 1880, M. Tangl described perforations in the cell membrane of the endosperm of *Strichnios, Phoenix, Areca.* In 1881, in my "*Recherches sur l'appareil tégumentaire des racines,*" I noted monocotyledonous tissues in which the cells communicate with each other by means of narrow canals. M. Strasburger, M. Russow (1882), M. Gardner (1882-3), M. Schaarschmidt (1884), have observed in various tissues, and especially in the albumen of a large number of grains, a similar arrangement, and have demonstrated it by means of staining materials.

[†] *Recherches sur l' appareil tégumentaire des racines*, Appendix; and *Revue Sci.*, vol. iii, p. 429 *et seq.*

[‡] *Lappa communis*, var. *major*, *Ruyschia Souroubea*, *Clusia Liboniana*, *Buxus sempervirens*, *Ruscus aculeatus*, etc.

[§] These canals therefore differ totally from the *culs-de-sac* in thick membranes which are often described under the defective name of canaliculi.

[‖] *Triticum vulgare, Scindaspus pertusus, Tornelia fragrans, Raphidophora pinnata, Ficus elastica, F. carica, Buxus sempervirens, Amorpha glabra, Cytisus alpinus, Robinia viscosa, Lunaria annua, Jasminum humile, Anthurium nitidum, Smilax excelsa, S. rotundifolia, Agave glauca.*

observed under the conditions just indicated, present here and there colorless lacunæ, at least in certain species of plants. In the second case, the walls of the cells are seen to stand out white upon a colored ground; the canals which traverse these walls are then visible because they are colored the same as the fundamental protoplasm itself.[*]

4. *Injection into organs.* I also tried to inject (slowly under pressure) into the organs to be studied a liquid capable of coloring the protoplasm; I then made cross sections of these organs. The injection rarely succeeded, but when it took place in a sufficiently uniform manner, this process led to a result identical with the preceding.[†]

IV. This unity (*ensemble*) of facts shows at least that in a great number of cases the cell walls permit the passage of protoplasm through narrow openings; so that in the tissues of a given plant, where up to a recent date we have only observed a multitude of small protoplasmic masses entirely isolated, there is in reality a single enormous protoplasmic mass.

It has seemed to me especially interesting to prove the existence of this structure in various parts of the same plant. For this purpose I have employed the box (*Buxus sempervirens*). Applying the methods 1, 2, 3, above mentioned, I have proved a continuity of the protoplasm in the stem and in the leaves of this shrub. From my investigations I am led to believe that in this species the protoplasm pursues, through incomplete cell walls, an uninterrupted course from the roots to the extremities of the leaves. *Ficus elastica* shows an analogous structure. The bearing of these facts on vegetable physiology and on natural philosophy will be considered in the near future.

[NOTE.—An English rendering of Dr. Schaarschmidt's paper "On the *Continuity of Protoplasm*," etc., may be found in *Nature*, Jan. 29, 1885, pp. 290–292. See also, *Nature*, Feb. 12, 1885, p. 337; Feb. 26, p. 290; and March 19, p. 459.—TR.]

GENERAL NOTES.

Esculent Plants of the Aborigines.—We are apprised that M. Paillieux, one of the Councillors of the French Society of Acclimatation, aided by M. Bois of the Museum of the Jardin des Plantes, are publishing a work on rare and curious esculent plants, and are anxious to bring as many of these as possible into cultivation in France. A request has reached us for seeds, bulbs or tubers, according to the species, of certain of our Western plants which the Indians use, or have used. By circulating the request in the BOTANICAL GAZETTE

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[*] I have colored especially: *Triticum vulgare*, *Ficus elastica*, *Buxus sempervirens*, *Robinia viscosa*, *Cytisus alpinus*, *Amorpha glabra*.

[†] *Cytisus alpinus*.